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QUANTITATIVE ANALYSIS OF ENERGY USAGE IN CENTRAL FOOD PREPARATION SYSTEM AT FORT LEE, VIRGINIA

by

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June 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of an energy evaluation of the Central Food Preparation System (CFPS) and three dining halls at Fort Lee, Virginia. As far as cooking was concerned, there were energy savings in cooking large batches of food with large equipment at CFPS vs. cooking small batches of food with small equipment at the individual dining halls. However, due to the extra steps required for freezing, storing, and reheating of the CFPF prepared entrees, there was an additional energy expenditure as compared to

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foods freshly prepared and served in dining halls. Concerning the preparation of salads, gelatin desserts, and slicing of cold-cut meats in the Ingredient Preparation Facility (IPF), there was a net energy savings in using IPF-prepared foods because of no cook-freeze system involved.

This report also presents data on comparisons of electricity vs. gas cooking and large batches vs. small batches. Considering different energy costs, electricity is ranked as the major energy cost, and the cost of heating water is second.

EXECUTIVE PRECIS

1. The information and data presented in this report are the result of an energy evaluation in the Central Food Preparation System (CFPS) and three dining halls (DH) at Fort Lee, Virginia. Two dining halls were used as satellite dining facilities in which CFPS-prepared foods were served; one dining hall was used as a non-satellite dining facility in which no CFPF-prepared foods were served. Thirty meters were installed to monitor energy usage in these buildings and in the major equipment at CFPF. The main objectives of this study were (a) to analyze the energy usage pattern of CFPS-prepared foods against foods prepared at individual dining halls and (b) to assess the energy costs.

2. The CFPS at Fort Lee can be divided into two subsystems -- the Central Food Preparation Facility (CFPF) and the Ingredient Preparation Facility (IPF). The CFPF is devoted to preparing entrees and bakery desserts. It employs a cook-freeze method. The IPF is devoted to preparing salads and gelatin desserts and to slicing cold-cuts. Only simple washing, shredding, etc., are involved. No cooking nor freezing is required.

3. In item-for-item comparisons, there were energy savings in cooking large batches of food with large equipment at CFPF against cooking small batches with small equipment at the individual dining halls. The average energy savings in cooking nine entrees at CFPF was 356 Btu per serving which is equivalent to 42% savings as compared to that cooked at dining halls. However, due to extra steps required

for preserving, storing, and reheating entrees prepared at CFPF, not only is the energy savings resulting from large batch cooking at CFPF lost, but there is a net energy loss of 177 Btu per serving, which is equivalent to an additional 21% energy expenditure.

4. The energy directly used for cooking, freezing, and frozen storage of foods prepared in CFPF is 796 Btu per serving (including entrees and bakery desserts). This is equivalent to about 35% of the total energy used for overall CFPF operation; the rest (65%) is used for space heating, overhead, and maintenance.

5. The energy directly used for IPF-prepared foods is very small, only an average of 24 Btu per serving. An item-for-item comparison was made on slicing roast beef. The energy savings of a large batch against a small batch was about 46%. This saving can be reasonably retained, because there are no extra steps required for serving IPF type products as required for CFPF-prepared foods. Due to changes and modifications, the equipment and cleaning arrangements in the IPF operation at Fort Lee have not been set up in a most efficient and logical manner.

6. The total energy required for preparing foods in CFPF is about 2,270 Btu per serving (including space heating), costing about 1.3¢ per serving; whereas the energy required for preparing IPF items is about 671 Btu per serving, costing about 0.22¢ per serving.

7. The total energy required for preparing and serving foods in a satellite dining hall is about 14,580 Btu per meal (with space heating), costing about 6.6¢ per meal; whereas the energy required for preparing and serving foods in a non-satellite dining hall is about 14,400 Btu per meal, costing about 6.5¢ per meal. The total energy required and the energy costs in individual dining halls can vary, depending on the size of dining halls, number of meals served, and type of foods prepared. Therefore, the data cited above should not be construed as universally applicable. Also, if electricity were used for cooking, the energy cost might be higher.

8. Comparisons were made on two big ovens in CFPF -- electric revolving oven vs. gas convection oven. Basically, they are different in design. The revolving oven can accommodate more servings of food such as roast beef that requires a large amount of space due to its height. On the other hand, the gas convection oven can accommodate more servings of products such as cookies and cakes that require flat areas. The gas convection oven used more Btu per serving than the electric revolving oven. The Btu ratio ranges from 2.3 to 1 to as high as 3.3 to 1 depending on the products. However, the higher efficiency advantage of the electric revolving oven is lost because, in general, thermal energy derived from electricity costs four times more than gas.

9. Electricity is still the highest major energy cost in either CFPF or dining hall operations. To our surprise, the heating

of water constitutes the second highest energy cost for satellite dining halls. The volume of hot water used in building #8402 is about 8,700 gallons per day.

10. It has been clearly demonstrated that there are energy savings advantages to loading ovens as full as possible and processing foods in large batches.

11. As a result of this energy evaluation, the IPF is considered to be energy viable, but the cook-freeze system at CFPF is not. More detailed information is included in the Recommendation Section.

PREFACE

The US Army Natick Research and Development Command was tasked to serve as technical advisor to the Troop Support Agency for the evaluation of the Central Food Preparation System at Fort Lee. Energy evaluation was one part of the total evaluation of the Central Preparation System. The overall objective of the energy evaluation was to analyze the energy usage pattern and to assess energy costs. The basic approach was to follow mass energy flow so as to evaluate how energies were utilized. To provide energy input data, thirty utility meters were installed at strategic points. Daily collection of total energy input, as well as collection of energy consumption at different steps of food preparation, was taken. This report summarizes these data collections, assesses the energy costs, and makes interpretations and recommendations.

The authors, specifically, would like to thank Messrs. D.L. Brookman and J.J. Oliver of the Directorate of Facilities Engineering at Fort Lee for their splendid efforts in specifying and installing all the meters needed for the evaluation. The authors would like to also thank LTC J.E. Turner, LTC B.G. Belcher, Messrs. M.E. McCormack, and R.L. Helmer of the Directorate of Concept and Systems Division, TSA, for their advice and support, and Ms M. Lewis, Messrs. R. Stanton, and E. Palco for their

efforts in collecting energy data. Thanks are extended to LTC C.S. Napoli, Director of Food Management, Fort Lee, Virginia, and his team members connected with the operation of CFPS for their constant assistance during the course of this study and also to our secretary, Ms Hilma Laakko, for her diligent effort in typing and editing the manuscript.

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QUANTITATIVE ANALYSIS OF ENERGY USAGE IN CENTRAL FOOD PREPARATION SYSTEM AT FORT LEE, VIRGINIA

I. INTRODUCTION

A. General.

The US Army Natick Research and Development Command (NARADCOM) was tasked to serve as a technical advisor to the Troop Support Agency (TSA) for the evaluation of Central Food Preparation System (CFPS) at Fort Lee. The Food Engineering Laboratory, one of several elements at NARADCOM involved in the conduct of the evaluation, was tasked to conduct one part of the evaluation plan: to determine energy utilization at the Central Food Preparation System.

To obtain actual and meaningful data on energy utilization, thirty monitoring meters were installed in buildings that house the Central Food Preparation Facility (CFPF), Ingredient Preparation Facility (IPF), two satellite and one non-satellite dining halls, and major equipment in CFPF. Because some utilities in dining halls are shared with other activities such as sleeping quarters and offices, extra meters were installed at strategic points so that energy consumed by other activities and energies used by dining halls only could be measured. The Facilities Engineer Directorate at Fort Lee was responsible for installing all these meters; NARADCOM personnel were responsible for compiling and analyzing the energy data; and personnel at the Concept and Systems Directorate of TSA acted as liaison and actually collected energy consumption data.

B. Objective

The objective of the energy evaluation was to obtain overall information on the energy usage pattern in the operation of CFPS.

It involved:

1. Analysis of energy consumption in preparing foods at CFPF compared to energy consumption in preparing and serving foods at individual dining halls.

2. Analysis of energy used directly for cooking, freezing, and storage compared to energy used for maintenance in CFPS operation.

3. Assessment of energy costs.

II. LITERATURE REVIEW

There are publications dealing especially with identification of energy utilization and energy auditing in the food service area. Dwyer et al. chose chicken products and chicken by-products for studying the food processing/food service industry.[1] Naughton et al. examined the relative intensity of energy used in various unit operations and the structure of overall mass energy flow to evaluate how fuels were used in citrus packing plants.[2] Singh employed a flow diagram to identify and quantify all mass and energy inputs, as well as to identify and quantify all mass and energy outputs.[3] Dietz and Forwalter pointed out that energy audit for a new plant or an existing facility can result in lowering energy consumption by 10% to 30%.[4] McProud studied energy requirements for individual stages of production of beef loaves for five simulated hospital food service systems. Three of these were on-premise systems: conventional, cook/chill, and cook/freeze. Two were assembly/serve systems:

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1 S.J. Dwyer, K. Unklesbay, N. Unklesbay, C. Dunlap. Identification of Major Areas of Energy Utilization in The Food Processing/Food Service Industry. University of Missouri - Columbia, Columbia, MO 65201.

2 M. Naughton, R.P. Singh, P. Hardt, and T.R. Rumsey. Energy Use in Citrus Packing Plants. Paper presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers at Chicago, IL.

3 R.P. Singh. Energy Accounting in Food Process Operation. Food Technology. 32(4): 40-44, 1978.

4 C.D. Dietz and J. Forwalter. Process Energy Audit Can Lower Energy Costs by 10% to 30%. Food Processing. P. 52-53, June 1978.

thaw/heat/serve and heat/serve.[5] Snyder pointed out that more energy was usually used in food service operations than was necessary and described, in principle, how food service equipment should be designed to conserve energy.[6] Swift et al. conducted studies comparing energy efficiencies of cooking and baking equipment when used for reheating bulk frozen foods. They also compared energy costs by using different energy sources for reheating frozen foods.[7]

In general practice, for conserving energy in the food service area, the Federal Energy Administration, now a part of the Department of Energy, published a comprehensive guide.[8] Midwest Research Institute, on behalf of the National Restaurant Association, published two reports: one deals with comparison of energy requirements

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[5] L. McProud. Energy Management in Production of Entrees in Hospital Food Service Systems. Ph.D. Dissertation. The University of Wisconsin, Madison, WI, 1977.

[6] O.P. Snyder. Comparative Energy Analysis of Electric and Gas Cooking Equipment. Society for the Advancement of Food Service Research. P. 51-60. Proceedings of the 32nd Conference, 1976.

[7] J. Swift, S.F. Conca, and J.M. Tuomy. Efficiency and Cost Factors in Re-thermalizing Frozen Foods in Foods in Typical Dining Hall Equipment. Technical Report, NATICK/TR-78/014, US Army Natick Research and Development Command, Jan 78.

[8] Federal Energy Administration. Guide to Energy Conservation for Food Service. Oct 75.

for meal preparation at home with meal preparation in a restaurant,[9] the other with energy conservation guidelines and energy management techniques which apply to restaurant operations to reduce consumption.[10]

In the Central Food Preparation area, Rahman et al. published production guides for vegetable entrees, soups, desserts, pastries, and salads for use in CFPF at Fort Lee.[11] Tuomey et al. published operation guides on meat entrees for use in CFPF at Fort Lee.[12] Nation's Restaurant News gave a general description of CFPF operation at Fort Lee.[13]

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9 R.O. Welch. The Energy Requirements of Meal Prepaation: A Comparison of Restaurant vs. Home. MRI Project No. 3889-D(R), Midwest Research Institute, Jul 12, 1974.

10 Midwest Research Institute. *Energy Management and Energy Conservation Practices for the Food Service Industry.* MRI Project No. 3985-D. Midwest Research Institute, Dec 1974.

11 A.R. Rahman, H. Gorfien, N. Kelley, G. Schafer, W. Swantak, and D.E. Westcott. Production Guides for Vegetable Entrees, Soups, Desserts, Pastries, and Salads. Developed for Use in Central Food Preparation Facilities, Fort Lee, Interim Facility. Technical Report 75-35-FEL (FEL-13), US Army Natick Research & Development Command, Natick, MA, Sep 1974.

12 J. M. Tuomy, J.W. McNutt, J. Swift, G.J. Legris, P.T. Burke, and F.A. Costanza. Meat Entree Operation Guides Developed for Use in Fort Lee Interim Central Food Preparation Facility. Technical Report, NATICK/TR-79/015, US Army Natick Research & Development Command, Natick, MA, Nov 1978.

13 Nation's Restaurant News. Central Commissary Could Supply Outside Base. Nation's Restaurant News. P. 37, Nov 27, 1978.

III. GENERAL DESCRIPTION OF THE CENTRAL FOOD PREPARATION SYSTEM AT FORT LEE

The CFPS at Fort Lee is divided into two subsystems -- the Central Food Preparation Facility (CFPF) and the Ingredient Preparation Facility (IPF).

Central Food Preparation Facility (CFPF)

The CFPF is devoted to preparing entrees and bakery desserts. Basically, it employs a cook-freeze method. The common requirement of this method is the availability of cooking and freezing facilities. The essential steps consist of: cooking, quick freezing, and frozen storage.

Ingredient Preparation Facility (IPF)

The IPF is devoted to preparing salads and gelatin desserts and to slicing cold-cuts. It also has the function of supplying the CFPF with mixed ingredients, and formed meats such as meat balls, salisbury steaks, swiss steaks, etc. The basic steps involve: simple washing, cutting, slicing, bagging, refrigerated storage, and other related processes depending on the products prepared. No cooking or freezing facilities are required.

A. General Arrangements.

The CFPF at Fort Lee is located in Building No. 6220, a former warehouse, machine shop and bowling alley. The floor plan of the building, after renovation for CFPF use, is shown in Fig. 1. The equipment installed in CFPF is listed in Table 1. The equipment

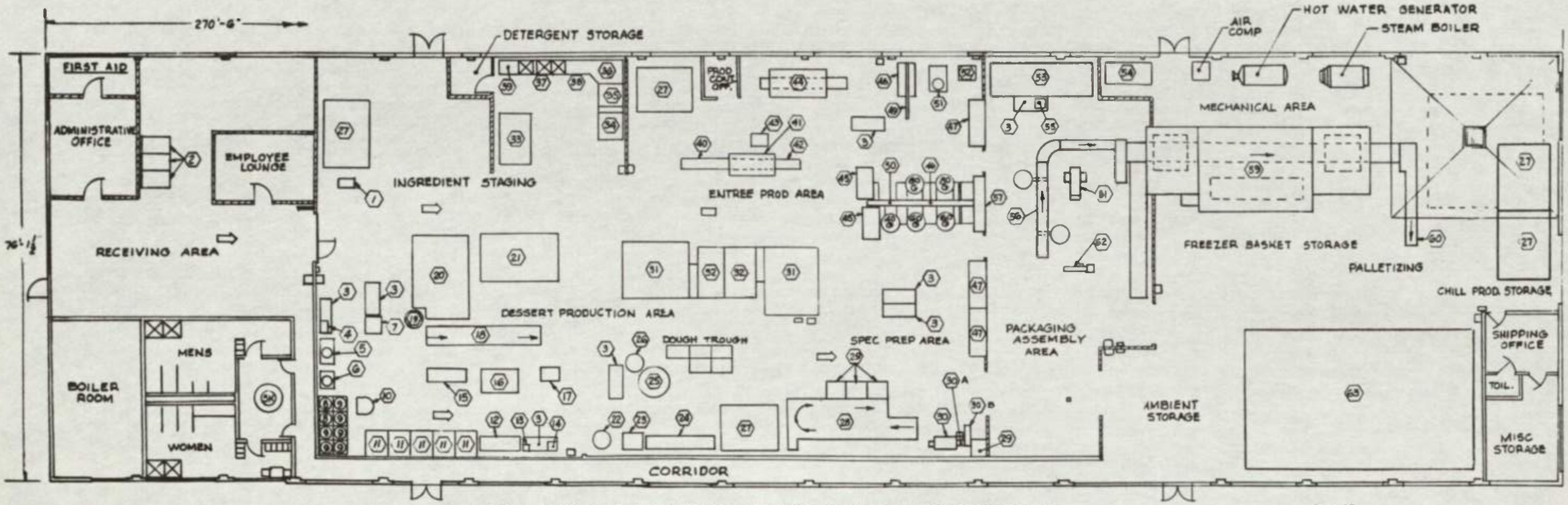

FIG. 1 FLOOR PLAN OF CENTRAL FOOD PREPARATION FACILITY AT FT. LEE, VA

TABLE 1.

Equipment List

CFPF Bldg No. 6220

Item Number

1. Scale
2. Skid
3. Table
4. Sifter, Flour
5. Mixer, Dough
6. Mixer
7. Bin, Mobile
8. Mixer
9. Mixer
10. Truck
11. Rack, Mobile
12. Refrigerator
13. Hot Plate
14. Mixer
15. Cutter, Cookie
16. Depositor, Batter
17. Depositor, Ring
18. Table, Production
19. Divider, Dough
20. Room Proofing
21. Room, Fermenting
22. Kettle, Jacketed w/Agitator
23. Mixer, Pie Dough
24. Divider, Dough
25. Pie Machine
26. Depositor, Pie Fill
27. Refrigerator, Walk-In
28. Doughnut Machine
29. Rack, Doughnut
30. Packaging Sealer, Bag

30a. Leader, Bag

30b. Conveyor, Bag Discharge

31. Oven, Revolving Tray
32. Oven, Convection, Roll-in
33. Washer, Pan Rack
34. Table, Drain
35. Table, Feed

TABLE 1. (Cont.)

36. Pot Wash Table

37. Sink Tubs/Drainboards

38. Wash Unit, Pot/Pan

39. Disposer

40. Breading Machine

41. Fryer, Continuous

42. Hoist (for Item #41)

43. Filter, Fat

44. Cooker, Steam

45. Pan, Fry-tilt

46. Kettle System

47. Freezer, Roll-in

48. Tank, Boil-in-bag

49. Hoist, Trolley (for Item #48)

50. Packaging Hoist, Trolley (for Item #56)

51. Mixer with Dolly

52. Pump, Chilled Water for Kettles

53. Ice Builder

54. Refrigerator Unit (for Item #53)

55. Slicer, Meat

56. Conveyor, Pkg/Proportioning

57. Pump, Food Transfer (Kettles)

58. Conveyor

59. Blast Freezer System

60. Carton Conveyor

61. Machine, Forming, Filling

62. Machine, Marking

63. Holding Freezer, Walk-in

item numbers in Table 1 correspond to equipment item numbers noted on Fig. 1. In general, the entree products are prepared at the Entree Production Area, and the bakery items are prepared at the Dessert Production Area, as shown on Fig. 1.

The Ingredient Preparation Facility (IPF) at Fort Lee is located in Building #7118 and is near CFPF Building #6220. Separate rooms in the IPF are designated for different functions, such as (1) lye peeling of potatoes and vegetable trimming; (2) washing, centrifuging, cutting, slicing, bagging, and preparing gelatin desserts; (3) slicing cold-cuts; (4) storing and weighing ingredients; and (5) refrigerated storage.

B. Meters Installed.

Meters have been installed in CFPF and IPF buildings for the measurement of energy consumption. Also, several major equipment items in CFPF have been individually metered. Table 2 lists only the 19 meters installed in the above two buildings. Fig. 2 shows the electric meter for measuring electricity fed to the CFPF Building #6220; and Fig. 3 shows the electric meter for measuring electricity consumption of the revolving tray oven.

C. Product Transfer.

In CFPS, unlike conventional dining halls, the foods are cooked and frozen (or refrigerated in the case of salads and gelatin desserts) in a central facility, transferred to a central storage facility, and then issued to dining halls for reheating and serving.

Table 2. List of Meters Installed in CFPF and IPF

CFPF - Building No. 6220

A. Measuring energy fed to the building and steam condensates.

1 Electric meter for 13.2-kV electricity feed to building.

1 Gas meter for gas feed to the building.

2 Hot water meters for steam condensates from No. 1 and No. 2 boilers.

1 Hot water meter for isolating steam condensate come-back from Bldg. 6231.

B. Measuring energy consumption of individual equipment items.

1 Gas meter on convection, roll-in oven (Item 32).

1 Gas meter on continuous fryer (Item 41).

1 Electric meter on compressor unit of blast freezer (Item 59).

1 Electric meter on fan unit of blast freezer (Item 59).

1 Electric meter on conveyor unit of blast freezer (Item 59).

1 Electric meter on walk-in, storage freezer (Item 63).

1 Electric meter on revolving tray oven (Item 31).

1 Electric meter on steam cooker (Item 44).

1 Electric meter on walk-in refrigerator.

IPF Building No. 7118

Measuring energy fed to the building and individual circuits.

1 Electric meter for 13.2 kV electricity feed to building.

3 Electric meters for circuits #1, #2, and #3.*

1 Meter stick for measuring oil feed to the boiler.

*Note: #1, #2, and #3 feed to three different panels.

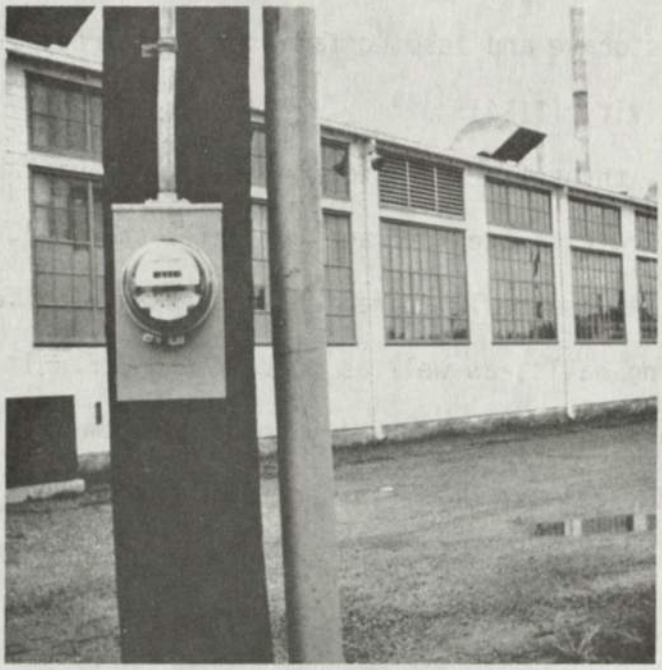

Fig. 2. Electric Meter for Measuring Electricity Fed to CFPF (Bldg. No. 6220).

Fig. 3. Electric Meter for Measuring Electricity Consumption of Revolving Tray Oven at CFPF.

The central storage and issuing facility is a Troop Issuing Subsistence Activity (TISA).

In TISA, three types of storage areas are available; namely, dry storage, refrigerated storage (or chill storage), and frozen storage. TISA issues all ingredients necessary for food preparation to dining halls, as well as to CFPF and IPF. It receives frozen prepared entrees and bakery desserts from CFPF, and refrigerated salads, gelatin desserts, and sliced cold-cuts from IPF. In turn, it issues all CFPF- and IPF-prepared food items to dining halls as requested. Fig. 4 shows the flow of product transfer at Fort Lee, Virginia.

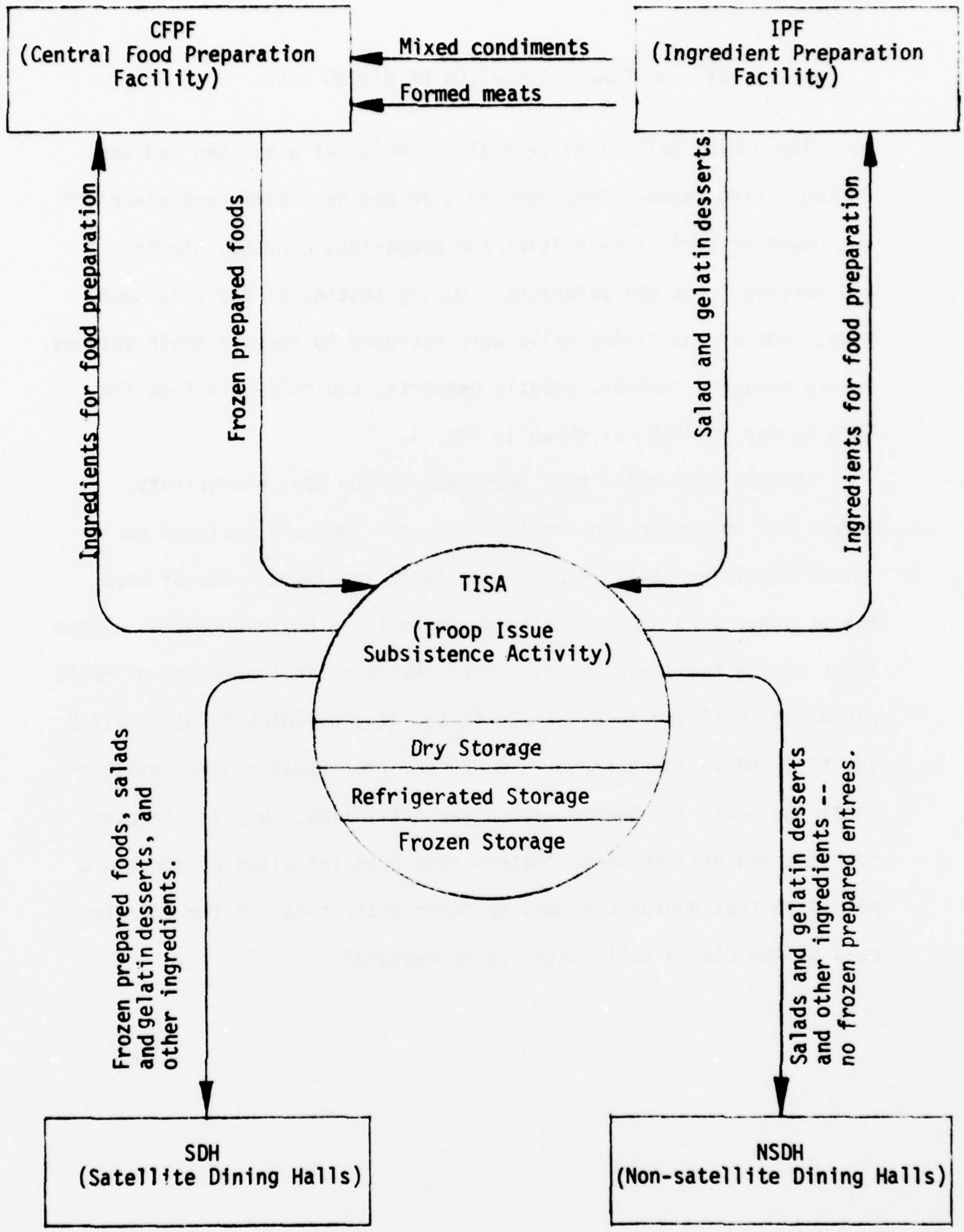

Fig. 4. PRODUCTS TRANSFER SYSTEM IN CENTRAL FOOD PREPARATION SYSTEM, FORT LEE, VIRGINIA

IV. GENERAL DESCRIPTION OF DINING HALLS

The dining halls (DH) generally consist of a kitchen and one or two dining rooms. They vary in size and have different pieces of equipment of various capacities for preparing, cooking, storing, and serving foods and beverages. During testing of the CFPS operation, some of the dining halls were assigned to receive their entrees, bakery desserts, salads, gelatin desserts, and cold-cuts from the CFPS by way of TISA, as shown in Fig. 4.

Three dining halls have been metered for gas, electricity, steam, and hot water consumption. Two of them were assigned as satellite dining halls -- buildings #8402 and #3701. One of them was assigned as a non-satellite dining hall -- building #3206. These three dining halls vary in size (and therefore in the number of meals per day): building #8402 -- 12,141 sq. ft., building #3701 -- 4,700 sq. ft., and building #3206 -- 9,029 sq. ft. Because some utilities in dining halls are shared with other activities, such as sleeping quarters and offices, extra meters have been installed at strategic points so that energy consumed by other activities and the energies used by the dining halls only can be measured.

V. METHODS AND PROCEDURES

Data collections in this study were taken during regular production time. No attempts were made to alter or to deviate from established procedures for the sake of energy auditing.

A. Production in CFPS.

The unit of production in CFPS is the number of servings. The size of servings differs from one product to another.

For example: Swiss steak - 1 piece, 6 oz.
Barbecued chicken - 2 pieces, 8 oz.
Roast beef - 2 slices, 4-1/2 oz.
Yellow cake - 1 piece, 3 oz.

The products and size of servings are indicated in Appendices A, B, C, and D. Major pieces of equipment in CFPF were individually metered; therefore, the energies required for cooking or freezing each serving could be taken directly from the individual meters and divided by the number of servings in a batch. The energies used for preheating an oven or a deep-fat fryer were not taken into account for figuring the Btu required for cooking, because these energies can vary significantly from one batch to another due to habits of personnel variations and due sometimes to conditions beyond control.

In IPF no cooking and/or freezing operations were involved; and no equipment was individually metered. The energy used for

washing, cutting, slicing, etc., was derived from the power rating of the equipment and multiplied by the time in use. The Btu per serving for foods prepared in IPF is small compared to those prepared in CFPF. The data are presented in Appendix C.

B. Production in Dining Halls.

The unit of production in dining halls is the number of meals served. The number of meals per day was derived from the total number of meals served at breakfast, lunch, and dinner. The energy input per day divided by the number of meals served a day is the energy required for preparing and serving one meal. When the data on energy required for cooking entrees for serving at non-satellite DH were needed for comparing with that at CFPF, the power rating of the cooking equipment was multiplied by the time the power was on. This approach for determining energy consumption without actually putting meters on cooking equipment has been proposed by Romanelli and has proven to be fairly accurate.[14] Nibi in his study of energy comparison in DH at Fort Lee has estimated that power-on time is about two-thirds of the time used in cooking.[15] This applies both to gas convection ovens and deep-fat fryers. Therefore, we have been using the power rating

[14] F. Romanelli. Evaluating Food Service Equipment for Energy Efficiency. Society for the Advancement of Food Service Research. P. 61-67. Proceedings of the 32nd Conference, 1976.

[15] J.P. Nibi. Estimated Energy comparison - Dining Facility, Bldg. 8400, Fort Lee, VA. Memorandum for Record, 20 Oct 77 (unpublished).

multiplied by two-thirds of the time used for cooking to obtain the energy usage data of the cooking equipment. These data are necessary for comparing the energy usage in cooking at DH with the cooking at CFPF.

C. Calculation Units.

Energy used as electricity, gas, steam and hot water was converted to Btu for ease in comparison. From literature[16, 17, 18] and from our measurements and estimation, the following conversion factors were used in our calculations:

Energy Conversion

Electricity	kWh x 3,413 = Btu
Gas	ft^3 x 1,000 = Btu
Steam	lb x 1,020 = Btu
Hot water	gal x 751 = Btu

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16 See Reference 8.

17 See Reference 5.

18 See Reference 10.

When electric equipment is in operation, and no meter is installed on the equipment, the equations for converting electricity into Btu are as follows:

For 3-phase electric power:

$$\text{kWh} = \frac{\text{Volts x Amps x Power factor x 1.723}}{1{,}000} \text{ x on time}$$

For single-phase electric power:

$$\text{kWh} = \frac{\text{Volts x Amps x Power factor}}{1{,}000} \text{ x on time}$$

Power factor = 0.85 (for induction motor)

Power factor = 1.00 (for resistance heating)

Cost Conversion

Electricity	4.0/kWh
Gas	3.0¢/10 ft^3
Steam	3.3¢/10 lb
Hot water	1.9¢/10 gal

VI. ENERGY USAGE IN THE CENTRAL FOOD PREPARATION SYSTEM

A. Overall Energy Usage.

During our study a daily record was kept on energy input to the CFPS. There were two separate periods of data taking which differed in terms of size of production in CFPF: 10 Oct to 19 Oct 78 and 23 Oct to 30 Nov 78. During the first period, production was increased from regular to near maximum capacity, and no steam was required for space heating due to warm weather. During the second period, production was decreased to normal, and steam was required for space heating. On the contrary, in IPF operation the production was increased in the second period. Appendix E gives a detailed accounting of input of the different energy sources and the servings produced, as well as the energies required for maintaining the facility overnight and weekends.

A summary of energy utilization in the CFPS at Fort Lee is shown in Table 3. It is a condensed version of Appendix E. The energy input for operation in Table 3, Row 1, includes all energy sources, such as gas, electricity, and steam, except steam used for space heating. The steam input for space heating, during the second period, is listed in Row 2. Two general conclusions can be drawn from the data presented in Table 3:

1. Within the production capacity limit, energy used per serving decreased as number of servings increased. This is shown in Row 5 of Table 3 where the Btu per serving in the increased production

TABLE 3. A SUMMARE OF ENERGY UTILIZATION AT CFPS

	CFPF - Building #6220		IPF - Building #7118	
	10-19 Oct 78 Increased Prod. Period, 10 days	23 Oct - 30 Nov 78 Reg. Prod. Period, 37 days	10-19 Oct 78 Regular Production 10 days	23 Oct - 30 Nov 78 Increased Production 37 days
1. Energy input for operation, Btu x 10^6	263.50	918.39	50.33	173.34
2. Steam input for space heating, Btu x 10^6	*	172.30	*	40.50
3. Total servings produced	174,658	479,847	84,596**	318,486**
4. Average servings produced/ production day	21,832	17,772	10,575	11,795
5. Btu/serving (excluding space heating)	1,508	1,914	595	544
6. Btu/serving (including space heating)	---	2,273	---	671

Notes:
*Space heating was not necessary during this period.
**Servings consist of salads, gelatin desserts, and cold-cuts.

period was 1,508 Btu per serving compared to 1,914 Btu per serving in the normal or decreased production period. This was also true at IPF when the production was increased during the second period of 23 Oct to 30 Nov 78, the energy used per serving decreased.

2. The energy used per serving at IPF was very low compared to energy used per serving at CFPF. This is because there was no cooking, freezing, or frozen storage involved in IPF prepared products. The processes used at IPF were mostly simple cutting or shredding and high speed equipment employed is generally powered with a fractional horsepower motor.

B. <u>Energy Accounting for Cooking and Serving Entrees and Bakery Desserts</u>.

An analysis was performed to account for the energy directly used in cooking at CFPF as compared to that used at dining halls. Table 4 lists the individual entrees and bakery desserts that were closely followed.

As can be readily seen, there are great energy savings in cooking large batches of food with large equipment at CFPF as measured against cooking small batches with small equipment at dining halls. The gas convection oven at CFPF is rated for 800,000 Btu per hour and usually cooks more than 1,000 servings per batch, whereas the gas convection ovens used in dining halls are much smaller rated at 30,000 Btu per hour to 105,000 Btu per hour and usually

TABLE 4. COMPARISON OF DIRECT ENERGY USED IN COOKING, BTU/SERVING

	Cooking in CFPF				Cooking in Dining Hall			
	Deep-Fat Fryer	Convection Oven	Steam Kettle	Total	Deep-Fat Fryer	Convection Oven	Steam Kettle	Total
1. Roast pork	*	951	*	951	*	1,313	*	1,313
2. Roast beef	*	912	*	912	*	1,010	*	1,010
3. Swiss steak	222	390	*	612	434	707	*	1,141
4. Barbecued chicken	375	211	*	586	*	1,320	*	1,320
5. Southern fried chicken	462	*	*	462	917	*	*	917
6. Salisbury steak	*	377	*	377	*	898	*	898
7. Chicken fried beef patties	244	*	*	244	353	*	*	353
8. Meat sauce for spaghetti	*	*	136	136	*	*	340	340
9. Chili Con Carne w/beans	*	*	116	116	*	*	309	300
10. Coffee cake	*	180	*	180				
11. Yellow cake	*	177	*	177				
12. Chocolate chip cookies	*	130	*	130				
13. Sugar cookies	*	98	*	98				
Average of Items 1-9**				488				844

Notes:

*Equipment not used in cooking.

**Average energy savings in CFPF cooking vs. Dining Hall cooking in Items 1-9 -- 844 Btu/serving - 488 Btu/serving = 356 Btu/serving.

cook less than 200 servings per batch. It should be noted that the energies listed in Table 4 for CFPF foods involve cooking only -- no freezing or reheating have been taken into account.

In item-for-item comparison of the first nine entrees listed in Table 4, the average energy savings in CFPF cooking over the dining hall cooking is 356 Btu per serving.

There are basically two types of food prepared at CFPF -- entrees such as meat and poultry, and bakery desserts such as cakes and cookies. Besides cooking, the entrees require quick freezing, frozen storage, and reheating; the bakery desserts do not require reheating -- only ambient temperature thawing in dining halls. In addition, cookies do not require quick freezing -- only frozen storage for preservation. Table 5 summarizes the total direct energies used for CFPF-prepared foods and compares them with dining hall prepared foods. Due to the extra steps required for freezing and reheating, it takes an additional average energy expenditure of 177 Btu per serving of CFPF-prepared foods over the freshly prepared foods at individual dining halls. Note that the additional energy expenditure of 177 Btu per serving represents an average comparison of the first nine items of CFPF prepared foods vs. dining hall prepared foods, as listed in Table 5. One of the nine entrees, Swiss steak, has a small energy savings of 36 Btu per serving in favor of CFPF-prepared foods. The other eight items that used CFPF-prepared foods instead of dining hall-prepared foods required more energy.

Table 5. COMPARISON OF TOTAL DIRECT ENERGY USED IN PREPARING, COOKING, AND PRESERVING (BTU/SERVING)

	CFPF Preparation	Dining Hall Preparation	Comparison of CFPF- vs. Dining Hall-Prepared Foods
1. Roast pork	1,495	1,335	+ 160 (+ 12.0%)
2. Roast beef	1,424	1,032	+ 392 (+ 38.0%)
3. Swiss steak	1,134	1,170	- 36 (- 3.1%)
4. Barbecued chicken	1,379	1,349	+ 30 (+ 2.2%)
5. Southern fried chicken	1,064	926	+ 138 (+ 14.9%)
6. Salisbury steak	977	907	+ 70 (+ 7.7%)
7. Chicken fried beef patties	752	362	+ 390 (+ 107.7%)
8. Meat sauce for spaghetti	567	349	+ 218 (+ 62.5%)
9. Chili Con Carne w/Beans	545	309	+ 236 (+ 76.4¢)
10. Coffee cake	338		
11. Yellow cake	326		
12. Chocolate chip cookies	193		
13. Sugar cookies	161		
Average of Items 1-9*	1,037	860	+ 177

Note:
*Average energy expended in CFPF-prepared foods vs. Dining Hall-prepared foods in Items 1-9: 1,037 Btu/serving minus 860 Btu/serving = 177 Btu/serving.

The additional energy required ranged from 30 to 392 Btu per serving. The additional energy expenditure of most entree items should be taken into consideration when the overall operation of CFPF is reviewed.

The detailed energy accounting data of CFPF-prepared individual items are listed in Appendices A and B and that of dining hall-prepared items in Appendix D. The energies used in each step of operation are listed in the appendices.

C. Energy Accounting on Preparing Salads, Gelatin Desserts, and Slicing Cold-cuts.

Table 6 lists the direct energy required for preparing salads (carrots are given as an example), gelatin desserts, and slicing cold-cuts in IPF. These data are taken from Appendix C in which energies required for preparing each serving at IPF are extremely small, since there were no cooking, freezing, or reheating steps involved.

D. Direct Energy Against Indirect Energy Used in Food Preparation at CFPS.

Direct energy in CFPS is defined as the actual energy used in preparing, cooking, freezing, and freezing storage of foods at CFPS. Energy used for preheating ovens, for bringing freezer temperatures down, etc., is not counted as direct energy. The gross energy registered in the meters installed for building services minus

Table 6. Direct Energy Used in Items Preparation at Ingredient Preparation Facility (Building #7118)

	Btu/serving
Carrot Shredding	33
Peach Gelatin Dessert	32
Slicing of Cold-Cut Meats	7

Average = 24 Btu/serving

direct energy is counted as indirect energy or overhead energy. Indirect energy includes that used for lighting, ventilation, pot and pan washing, general cleaning, refrigerated storage of raw materials, preheating of equipment, and maintaining an office and facilities overnight and over weekends even when there is no production. Table 7 shows Energy Accounting of CFPF and IPF Operations. In CFPF the direct energy used in cooking, freezing, and frozen storage is about 35% of the total energy input; in IPF the direct energy used for equipment operation is 4% of the total energy input.

Table 7. Energy Accounting of CFPF and IPF Operations

	CFPF	IPF
1. Direct energy used Btu/serving	796	24
2. Energy used for space heating Btu/serving	359	127
3. Indirect energy used for maintenance and operation Btu/serving	1,118	520
4. Total energy input Btu/serving	2,273	671
5. Direct energy vs. total energy input, %	35%	4%
6. Cost/serving (¢)	1.29	0.22

NOTE: Economical analysis of cost/serving is shown in Appendix G.

VII. ENERGY USAGE AT DINING HALLS

During the study, a daily record was kept on energy input to three dining halls assigned for energy evaluation. Appendix F gives a detailed accounting of input for different energy sources and the steam required for space heating. The accounting is summarized in Table 8.

Buildings #8402 and #3701 were used as satellite dining halls while building #3206 was used as a non-satellite dining hall. Theoretically, building #3206 should have used less Btu per meal than buildings #8402 and #3701, since the non-satellite dining hall does not receive CFPF-prepared entrees. An examination of the data in item 6, Table 8, shows that the Btu per meal used at building #3206 was much higher than at building #3701. The explanation of the relatively lower energy consumption in building #3701 may lie in its disproportionately higher number of meals served per day as shown for item 5, Table 8. Building #3701 served 1,050 meals per day in an area of 4,700 sq ft, which has a meal-to-area ratio of 0.223 to 1; whereas in building #3206 the meal-to-area ratio is 0.072 to 1; and in building #8402 the ratio is 0.131 to 1. Within a limited range, indications are that the larger the meal-to-area ratio, the smaller the energy consumption. This may also explain why the satellite dining hall (building #8402) shows essentially the same energy expenditure as the non-satellite dining hall (building #3206) -- 14,580 Btu per meal for satellite dining hall vs. 14,400 Btu per meal for non-satellite dining hall, even though the former has been charged for the energy required for preparing CFPF foods and the latter has not.

Table 8. A Summary of Energy Utilization at Dining Halls

		Bldg. 8402	Bldg 3701	Bldg. 3206
		12,141 sq ft Oct 23-Nov 30	4,700 sq ft Oct 23-Nov 30	9,029 sq ft Nov 13-Nov 30
1.	Total energy input for operation, w/space heating Btu x 10^6	657.74	272.94	136.06
2.	Energy received from CFPS prepared foods, Btu x 10^6	198.61	105.78	5.44
3.	Total meals served.	58,753	35,704	9,829
4.	No. of Production days	37	34	15
5.	No. of meals served per day	1,588	1,050	655
6.	Btu/meal (w/ space heating)	14,575	10,593	14,396

VIII. STUDIES OF EQUIPMENT UTILIZATION

Questions have often been raised on the merits of using electric cooking instead of gas cooking, considering both efficiency and cost. Also energy information is required on the importance of batch size in cooking.

A. Comparison of Electric Revolving Oven vs. Gas Convection Oven.

There are four large ovens of comparable size in CFPF at Fort Lee -- two electric revolving ovens rated at 57.6 kW each and two gas convection ovens rated at 800,000 Btu per hour. The trays in the electric ovens revolve in a circular manner like a ferris wheel to achieve product temperature uniformity, whereas the products on the shelves of the gas ovens are stationary and depend on a forced-air blower for convection heating. In general, the revolving ovens can accommodate more servings of products such as roast beef, roast pork, turkeys, etc., which due to their height require a larger amount of air space than the gas convection ovens. On the other hand, the revolving ovens cannot accommodate as many servings of products that require flat areas, such as cookies, cakes, salisbury steaks, meat loaves, etc., as the convection ovens can. These comparisons are shown in Table 9. Also shown in Table 9 are direct comparisons of energy consumption in terms of Btu per serving in these two ovens. As can be readily seen, the gas convection oven uses more thermal energy in terms of Btu per serving than the electric revolving oven.

Table 9. Comparison of Gas Convection Oven Against Electric Revolving Oven

Products cooked	Gas Convection Oven: No. servings/oven load	Gas Convection Oven: Btu/serving	Electric Revolving Oven: No. servings/oven load	Electric Revolving Oven: Btu/serving	Ratio of Gas to Electricity in terms of Btu/serving
Chocolate chip cookies	1,536	130	600	51	2.5 to 1
Coffee cake	1,664	180	1,330	80	2.3 to 1
Yellow cake	1,728	174	1,176	64	2.7 to 1
Salisbury steak	1,088	377	912	135	2.8 to 1
Roast beef	1,296	912	1,620	272	3.3 to 1

The ratios are from 2.3 to 1 to as high as 3.3 to 1 in favor of the electric oven. However, the cost of electricity in general is about four times as high as gas.* This makes electric cooking less attractive than gas cooking as far as economy is concerned.

American Gas Association conducted an energy ratio study in 1949 on two similar cafeteria kitchens utilizing different energy sources -- one gas and the other electricity.[19] It was found that the overall energy ratio of cooking one meal was 1.65 to 1 (gas to electricity ratio). Our data on oven cooking alone shows a ratio of 2.3 to 1 and as high as 3.3 to 1. This high gas-to-electricity ratio in our data was probably due to the forced-air blower in the gas convection oven that caused air leakage through the oven door, especially when it was opened for inspection of food and losses in the exhaust system.

B. Comparison of Batch Size in Cooking.

As can be expected, decreasing the batch size in an oven increases the energy consumption in terms of Btu per serving, as shown in Table 10. Also, decreasing the batch size of sliced meats increases the energy consumption per serving, due to additional energy required for cleaning and sanitizing the meat slicer.

*The cost of electricity is based on 4¢/kWh and natural gas on 3¢/10 cu ft.

19 American Gas Asso., Inc. Commercial Kitchens. Chap. XIV. Fuel and Energy Computations and Comparisons. 1968. American Gas Asso., Inc., 605 Third Ave., New York, NY 10016.

Table 10. COMPARISON OF BATCH SIZE IN ENERGY UTILIZATION

Equipment Used	Product	Large Load		Small Load		Energy Savings Due to Large Load, %
		Number of Servings	Btu/Serving	Number of Servings	Btu/Serving	
1. Gas Convection Oven	Swiss Steak	1,280	390	670	448	13
	Barbecued Chicken	1,372	204	1,028	252	19
2. Electric Revolving Oven	White Cake	1,200	56	312	109	49
3. Meat Slicer	Roast Beef	5,160*	7	180**	13	46

Notes:
*Sliced at CFPF
**Sliced at dining hall

IX. ECONOMIC ANALYSIS

A. Energy Costs in Central Food Preparation System.

The economic analysis of energy costs depends not only on the amount of energy consumed but also on the type of energy utilized. Table 11 summarizes energy costs per serving of food in CFPF and IPF. The detailed data of energy costs are shown in Appendix G.

Since water in CFPF and IPF is heated by the steam used for daily operation, there is no separate cost for hot water. Electricity is the major cost in CFPF; but steam, which includes hot water, is the major cost in IPF. It should be noted that foods prepared in CFPF are entrees and bakery desserts which require higher energy expenditures than the salads, gelatin desserts, or slicing of cold-cuts prepared in IPF which do not require cooking and freezing. Therefore, we would expect the energy cost in CFPF to be much higher than IPF. Also, as shown in Table 11, energy cost per serving in the period of increased production was lower than that in the period of regular production.

B. Energy Costs in Dining Halls.

Table 12 summarizes energy costs per meal served in satellite dining halls, buildings #8402 and #3701; and non-satellite dining hall, building #3206. Details of energy costs are listed in Appendix H.

Electricity is still the prime major cost in energy expenditures of either satellite or non-satellite dining halls. Hot water constitutes the second energy expenditure for satellite dining halls. The volume of water used in building #8402 is about 8,700 gallons per day, which is

Table 11. ENERGY COSTS OF CENTRAL FOOD PREPARATION SYSTEM

	CFPF - Building #6220		IPF - Building #7118	
	10-19 Oct 78 Increased Prod. Period, 10 days	23 Oct - 30 Nov 78 Reg. Prod. Period, 37 days	10-19 Oct 78 Reg. Production 10 days	23 Oct - 30 Nov 78 Increased Production 37 days
1. Gas, Cost ($)	220	640	Not used	Not used
2. Electricity, Cost ($)	970	3,756	7	34
3. Steam (for operating), Cost ($)	345	1,244	161	551
4. Steam (for space heating), Cost ($)	151*	577	35*	131
5. Total energy cost ($)	1,686	6,197	203	716
6. Total number of servings produced in period	174,658	479,847	84,596	318,486
7. Numbers of servings produced/ production day	21,832	17,772	10,575	11,795
8. Cost/serving (¢)	.97	1.29	.24	.22

Note:

*Projected (not actual measurements).

Table 12. ENERGY COSTS OF DINING HALLS

	Satellite		Non-Satellite
	Building #8402 23-30 Nov 79 37 days	Building #3701 23 Oct - 30 Nov 79 34 days	Building #3206 13 Nov - 30 Nov 79 15 days
1. Dining room area, sq. ft.	7,656	2,667	4,173
2. Gas, Cost ($)	228	137	58
3. Electricity, Cost ($)	1,198	647	299
4. Steam (operating), Cost ($)	504	69	43
5. Steam (space heating), Cost ($)	267	93	131
6. Hot water, Cost ($)	610	307	94
7. Servings received from CFPS, Cost ($)	1,091	572	16
8. Total energy, Cost ($)	3,898	1,827	641
9. Total number of meals served	58,753	35,704	9,829
10. Average number of meals served/serving day	1,588	1,050	655
11. Cost/meal (¢)	6.6	5.1	6.5

equivalent to about 5.5 gallons of hot water for each meal served.

The energy cost per meal in building #3701 is rather low because of the disproportionately high rate of numbers of meals served per day. In ordinary operation, we would conclude that the energy cost for operating a non-satellite dining hall is about 6.5¢ per meal and for a satellite dining hall 6.6¢ per meal (including the energy costs of servings received from CFPF). It should be pointed out that the energy costs which are derived from the amount of energy used can vary, depending on the size of dining halls, number of meals served, and the type of foods prepared. Therefore, the data collected and presented in this report should not be construed as universally applicable.

X. RECOMMENDATIONS

1. More energy is required to serve cook-freeze foods prepared at CFPF than freshly prepared foods in dining halls. Since the additional energy required is about 177 Btu per serving for using CFPF-prepared foods (equivalent to an additional 21% for preparing foods at CFPF), the cook-freeze system at CFPF can be considered viable only when this negative energy burden can be compensated for by other advantages due to central preparation.

2. On the other hand, there is no cook-freeze system employed at the Ingredient Preparation Facility (IPF). In a comparison of meat slicing, the energy saved is about 46%. Although the energy required for preparing IPF type of food (salads, gelatin desserts, and slicing cold-cuts) is small -- an average of 24 Btu per serving -- the IPF prepared foods do have an energy advantage over similar items prepared at the individual dining halls. The advantages are mainly due to the preparation of large batches of foods and the use of larger and more efficient equipment. The concept of IPF is viable, but it is recommended that a more logical arrangement of equipment and cleaning process (e.g., straight line operation) be considered and, taking other factors into consideration, that a broader adaptation of IPF operation to other military installations be considered.

3. The use of electricity vs. gas for cooking was compared in a preliminary way. The indication was that, although electric cooking

is more efficient (less Btu used for cooking one serving) than gas cooking, the cost of using electricity for cooking is still rated higher than gas; therefore, changing from gas to electric cooking is unwarranted as long as gas is available and the price structure has not changed.

4. It has been clearly demonstrated in this study that the operation of a large batch of product at one time and more fully-loaded ovens have distinct energy advantages (less Btu per serving). Therefore, the above mentioned operations should be encouraged.

5. Considering different energy costs, electricity is ranked as the major energy cost in CFPF or dining hall operation. The cost of heating water constitutes the second. The volume of hot water metered for building #8402 use is about 8,700 gallons per day. In view of the large volume of hot water usage, the utilization of hot water in dining halls should be investigated.

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XII. APPENDICES

A. Direct Energy Consumption for Preparing Entrees at Central Food Preparation Facility

B. Direct Energy Consumption for Preparing Bakery Desserts at Central Food Preparation Facility

C. Products Prepared in Ingredients Preparation Facility

D. Direct Energy Consumption for Preparing Entrees at Dining Halls

E. Energy Accounting of Central Food Preparation System

F. Energy Accounting of Dining Hall Operation

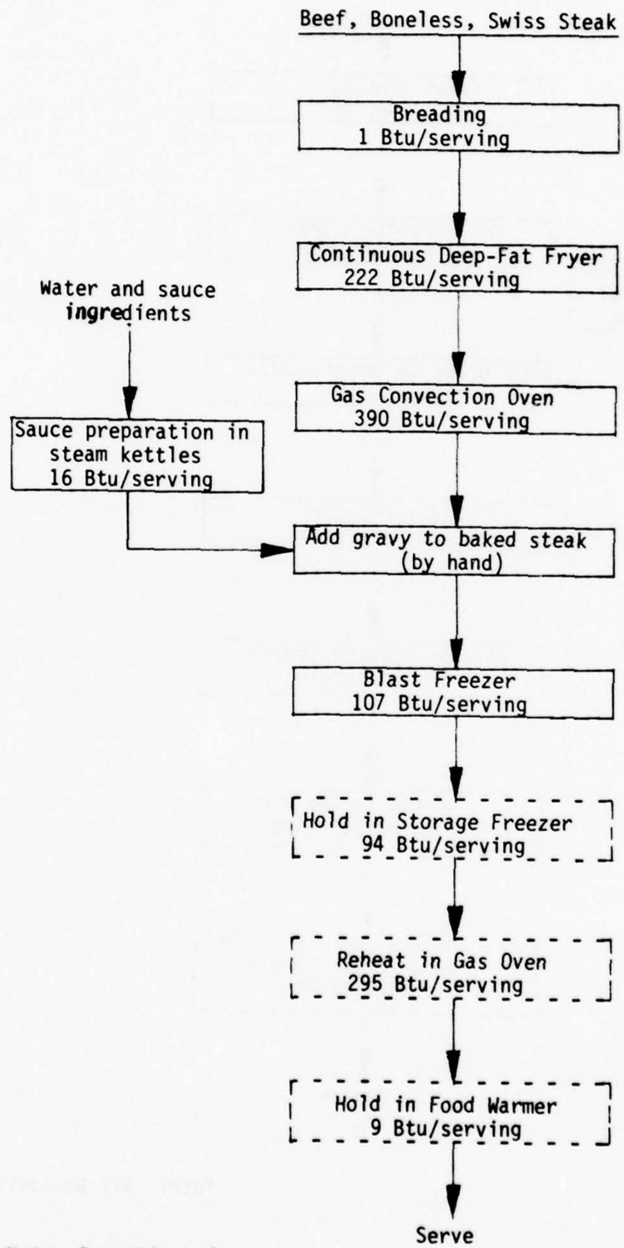
G. Economic Analysis of Energy Costs in Central Food Preparation System

H. Economic Analysis of Energy Costs in Dining Hall Operation

APPENDIX A

DIRECT ENERGY CONSUMPTION OF PREPARING ENTREES AT CFPF

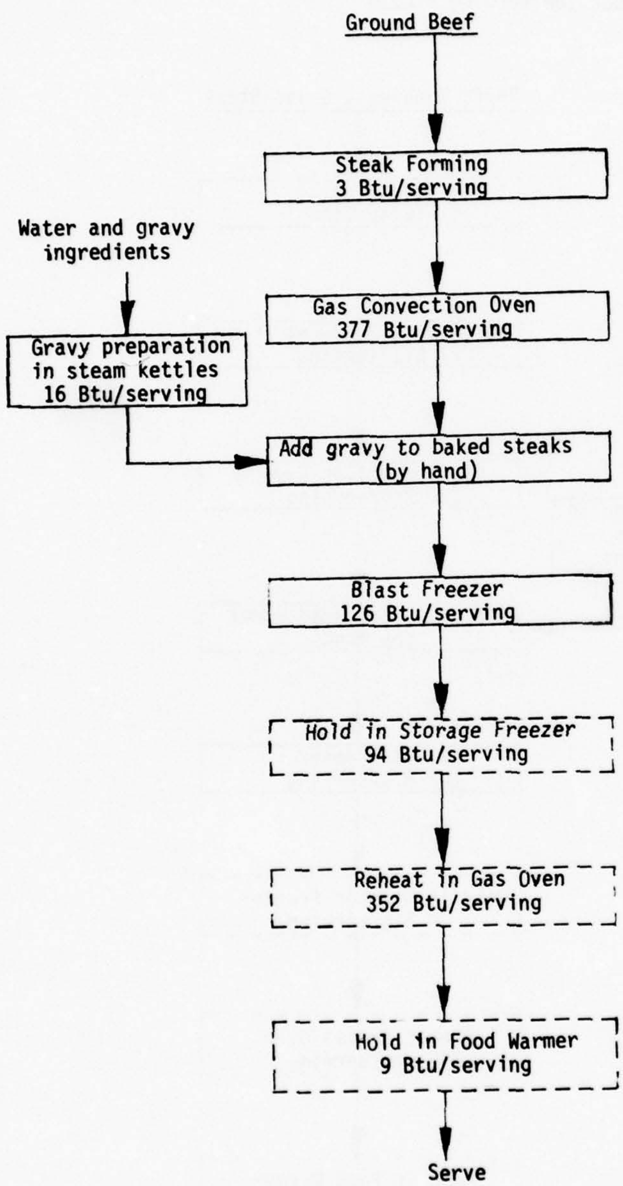
1. Swiss Steak (ea serving 6 oz.)



Note: Operations in dotted lines were performed in dining halls.

Total 1,134 Btu/serving

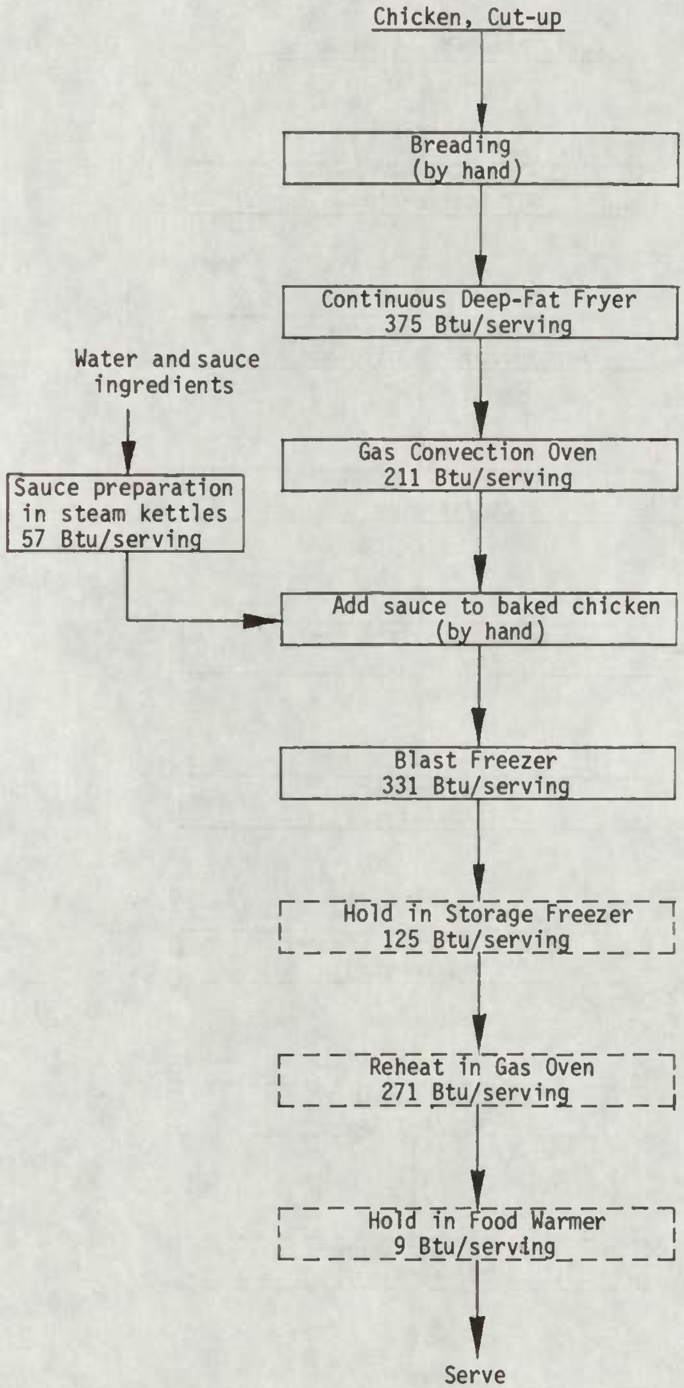
2. Salisbury Steak (ea serving 6 oz.)



Total 977 Btu/serving

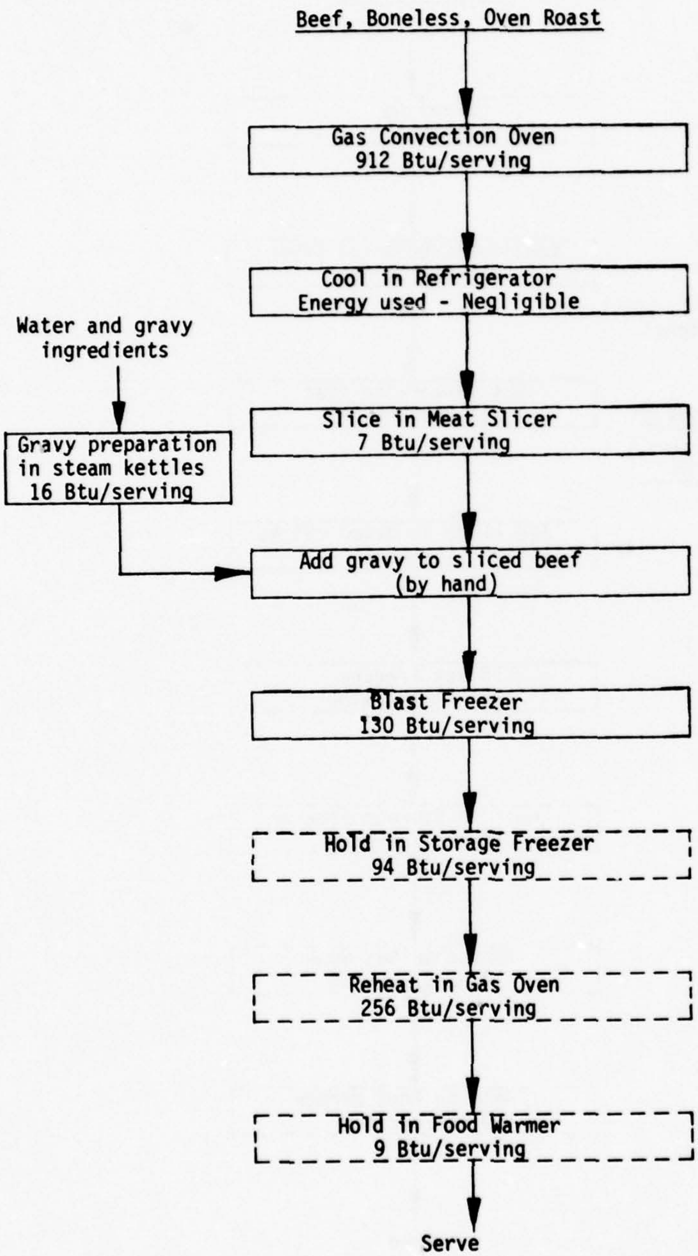
APPENDIX A (Cont.)

3. Barbecued Chicken (ea serving: 2 pieces, 8 oz.)



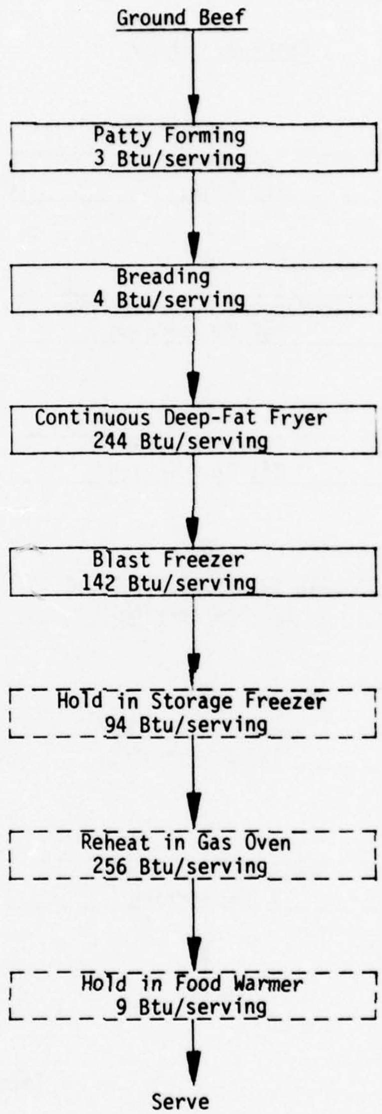
Total 1,379 Btu/servi

4. Roast Beef (ea serving: 2 slices, 4 1/2 oz.)



Total 1,424 Btu/serving

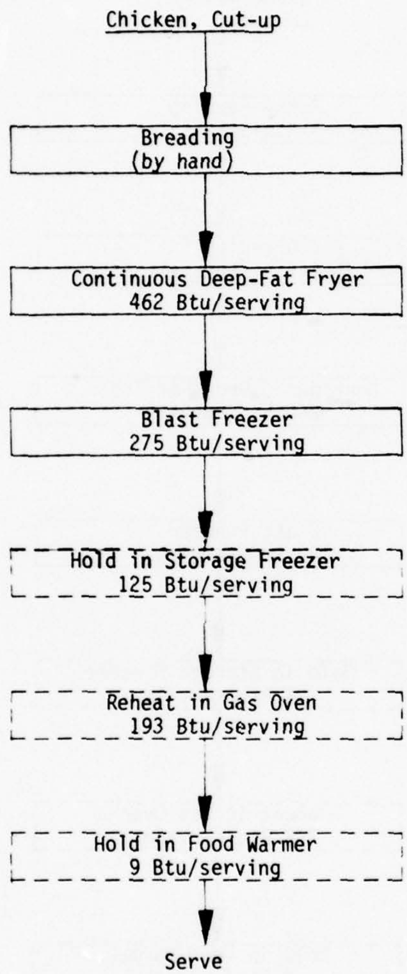
5. Chicken Fried Beef Patties (ea serving: two 3-oz. patties)



Total 752 Btu/serving

APPENDIX A (Cont.)

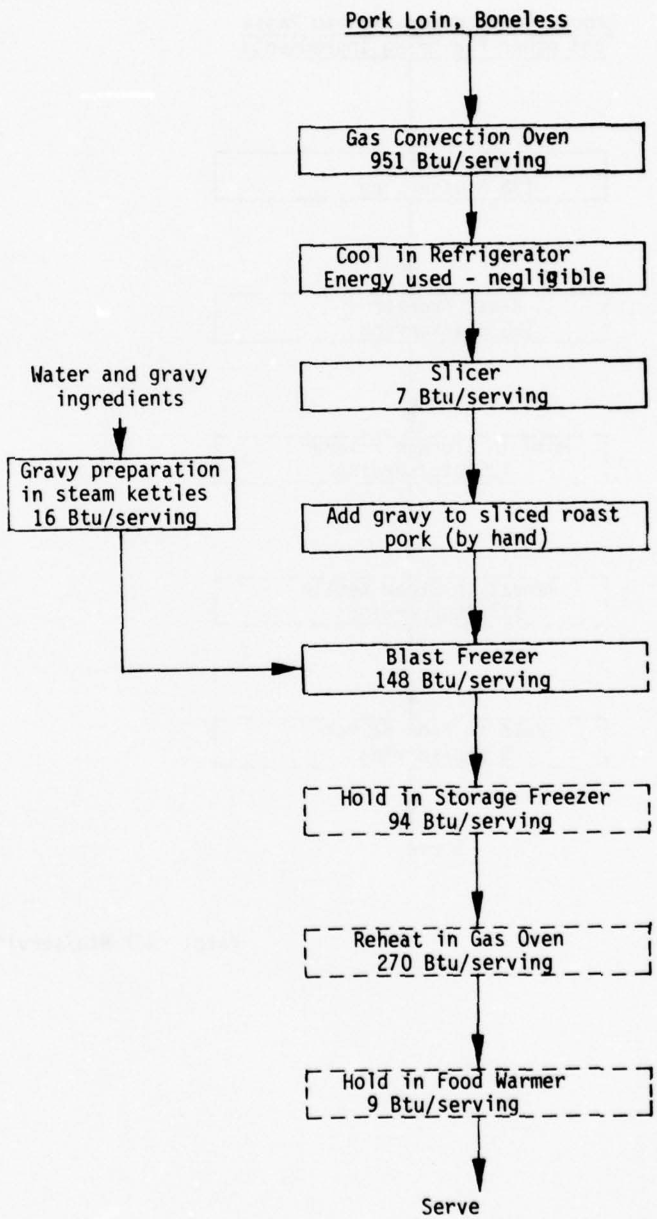
6. Southern Fried Chicken (ea serving: 2 pieces, 8 oz.)



Total 1,064 Btu/serving

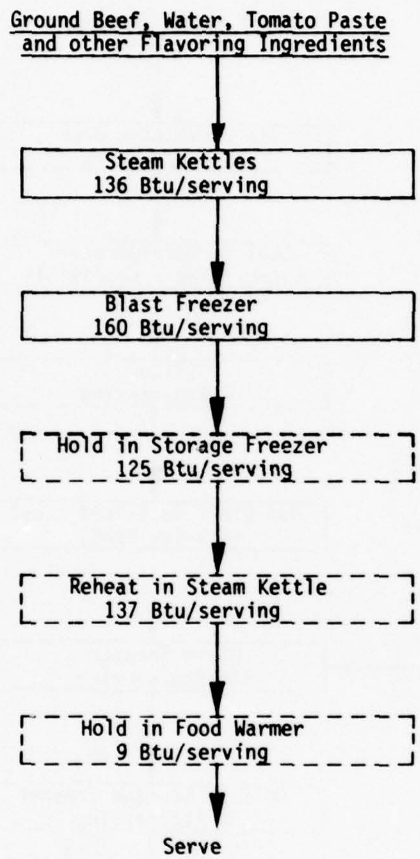
APPENDIX A (Cont.)

7. Roast Pork (each serving - 2 slices, 4-1/2 oz.)



Total 1,495 Btu/serving

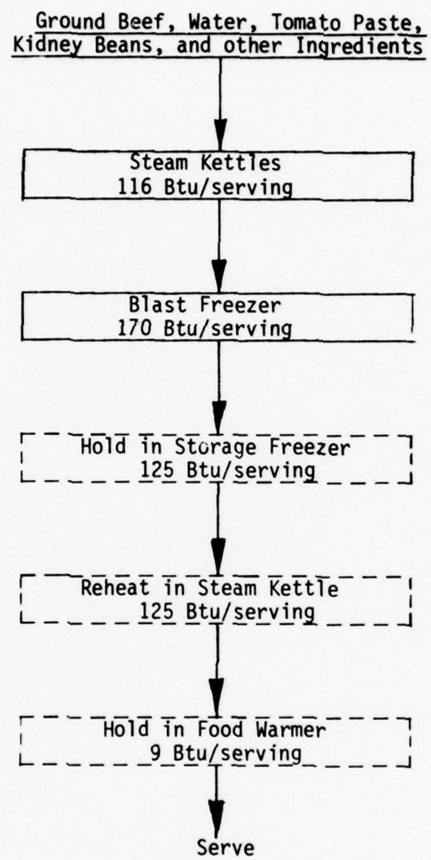
8. Meat Sauce for Spaghetti (each serving - 1-1/4 cup)



Total 567 Btu/serving

APPENDIX A (Cont.)

9. Chili Con Carne with Beans (each serving - 1-1/4 cup)

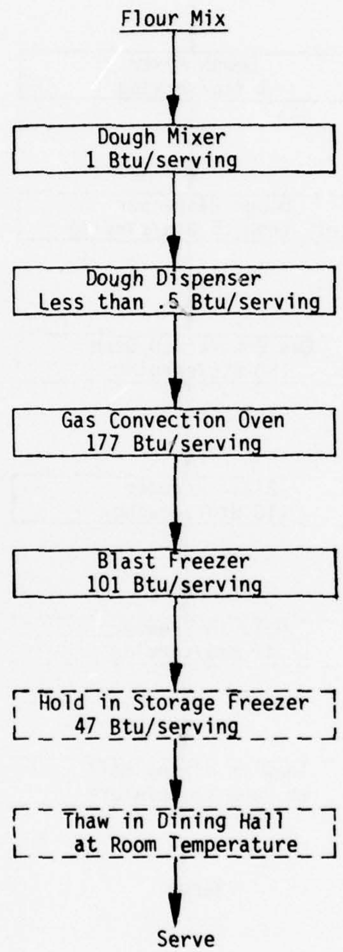


Total 545 Btu/serving

APPENDIX B

DIRECT ENERGY CONSUMPTION FOR PREPARING BAKERY PRODUCTS AT CFPF

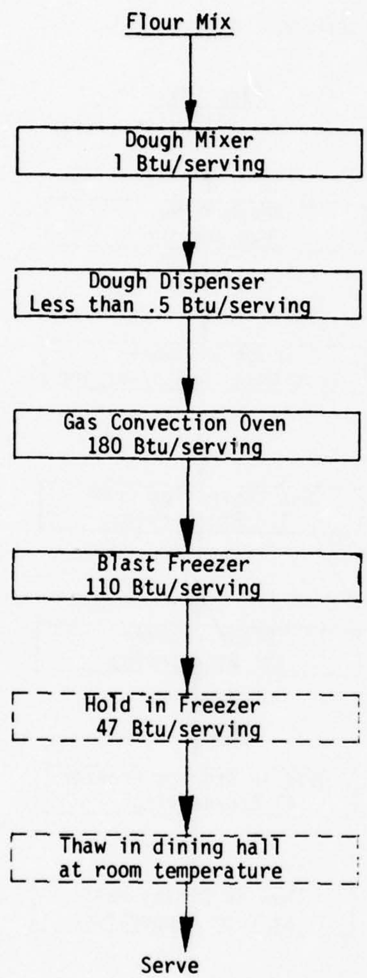
1. Yellow Cake (each serving - 3 oz.)



Total 326 Btu/serving

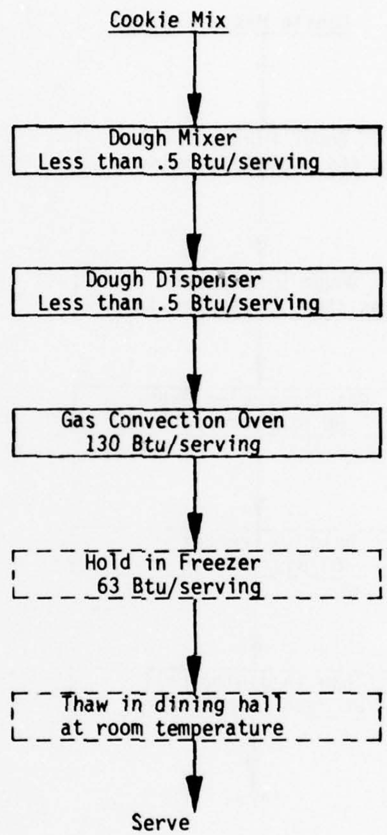
APPENDIX B (Cont.)

2. Coffee Cake (each serving - 3 oz.)



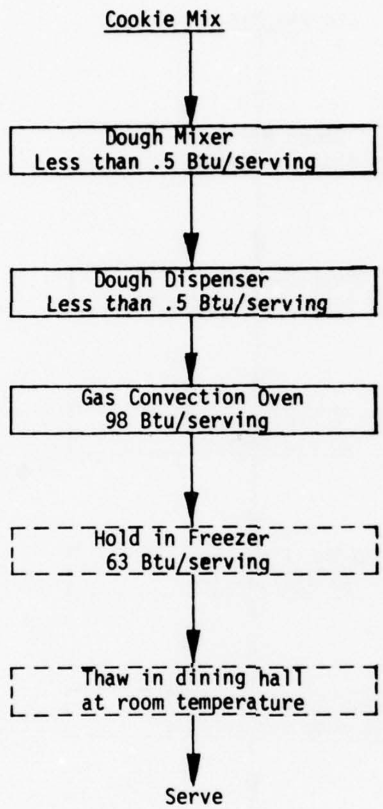
Total 338 Btu/serving

3. Chocolate Chip Cookies (each serving - two 2-oz cookies)



Total 193 Btu/serving

4. Sugar Cookies (each serving - two 2-oz. cookies)

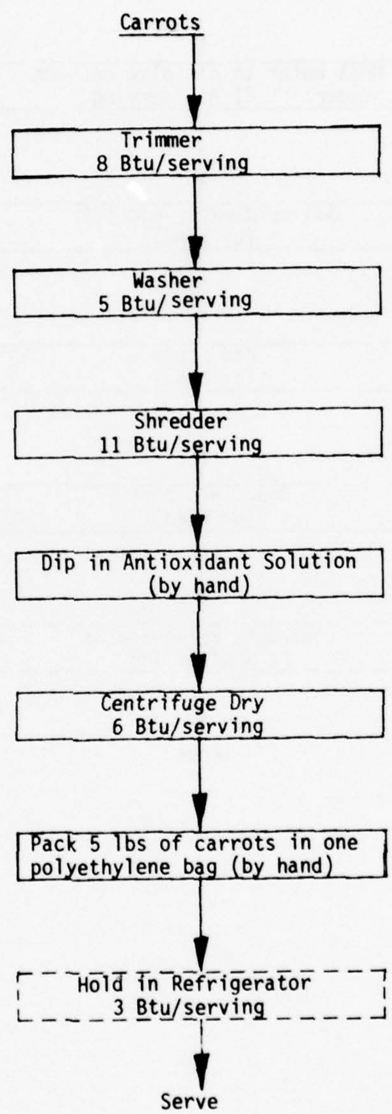


Total 161 Btu/serving

APPENDIX C

PRODUCTS PREPARED IN INGREDIENTS PREPARATION FACILITY
(Bldg 7118)

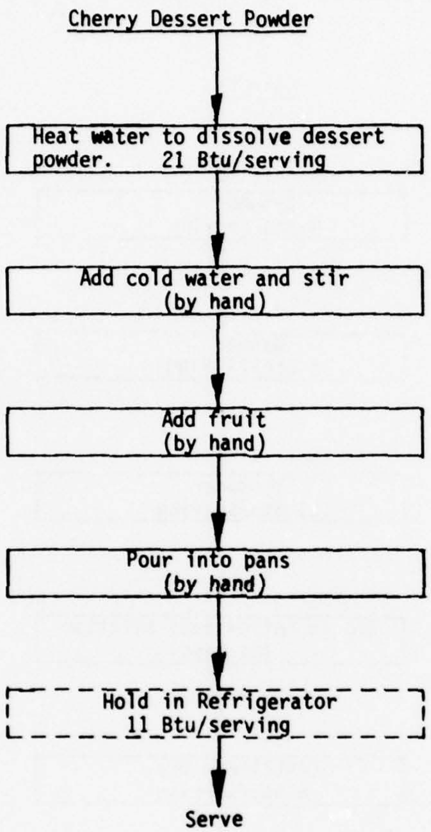
1. Carrot Shredding (each serving - 1.6 oz.)



Total 33 Btu/serving

APPENDIX C (Cont.)

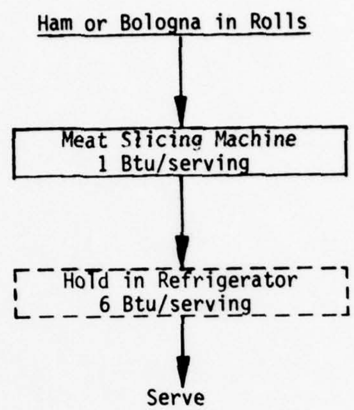
2. Peach Gelatin (each serving - 5.3 oz.)



Total 32 Btu/serving

APPENDIX C (Cont.)

3. Slicing of Cold-Cut Meats (each serving 3.2 oz.)

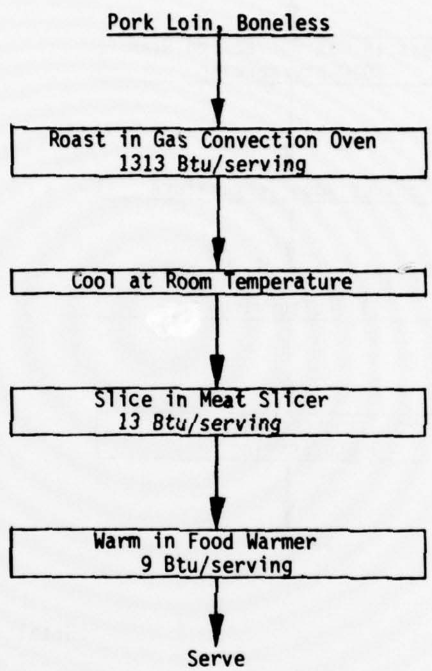


Total 7 Btu/serving

APPENDIX D

DIRECT ENERGY CONSUMPTION FOR PREPARING ENTREES AT DINING HALLS

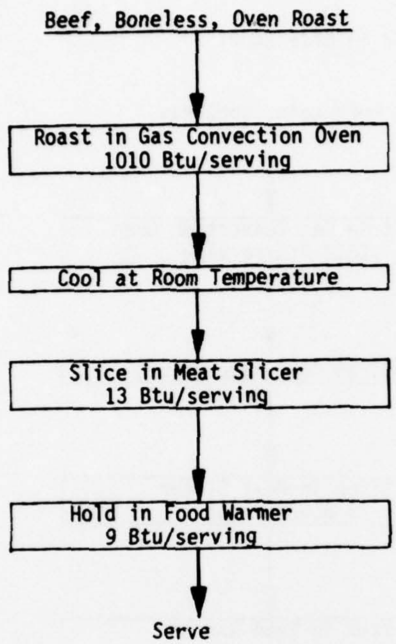
1. Roast Pork (prepared in Bldg 8402)



Total 1,335 Btu/serving

APPENDIX D (Cont.)

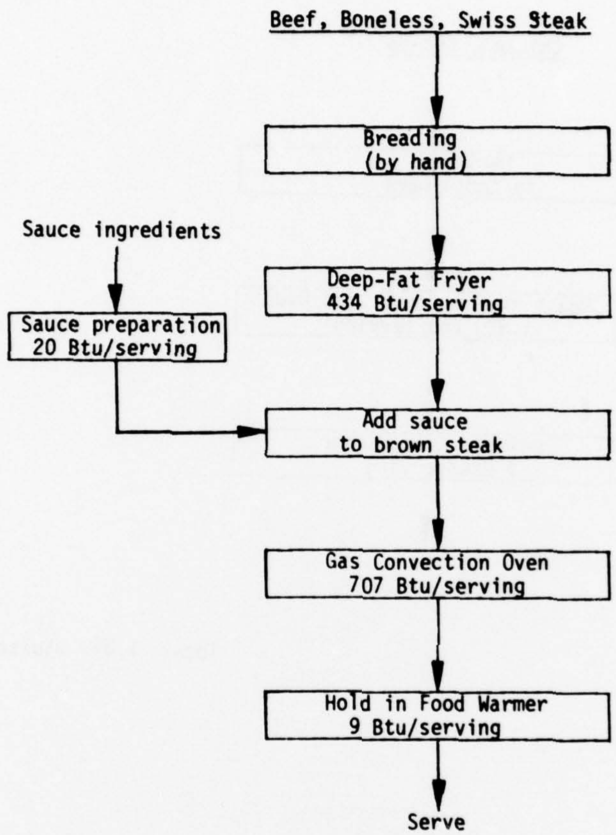
2. Roast Beef (prepared in Bldg 3206)



Total 1,032 Btu/serving

APPENDIX D (Cont.)

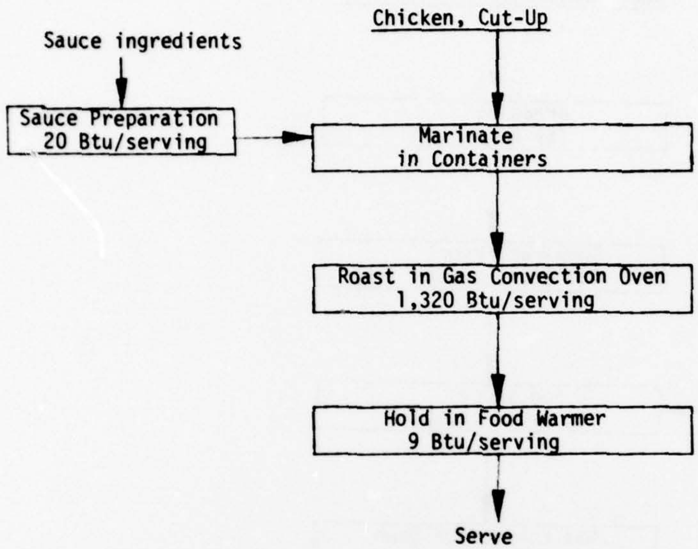
3. Swiss steak (prepared in Bldg 3206)



Total 1,170 Btu/serving

APPENDIX D (Cont.)

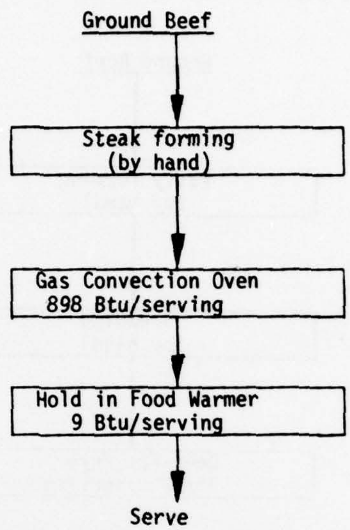
4. Barbecued Chicken (prepared in Bldg 3206)



Total 1,349 Btu/serving

APPENDIX D (Cont.)

5. Salisbury Steak (prepared in Bldg 3206)

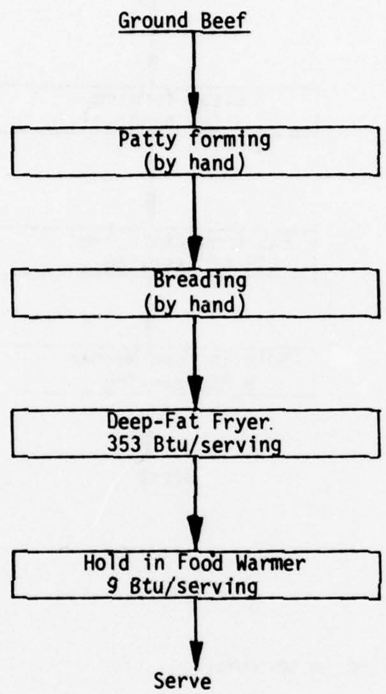


Total 907 Btu/serving

Note: No gravy used in serving.

APPENDIX D (Cont.)

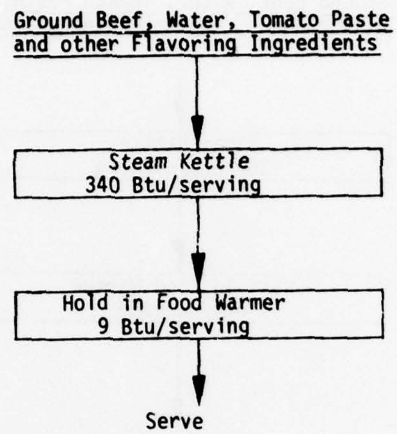
6. Chicken Fried Beef Patties (prepared in Bldg 3206)



Total 362 Btu/serving

APPENDIX D (Cont.)

7. Meat Sauce for Spaghetti (prepared in Bldg 3206)



Total 349 Btu/serving

8. Chili Con Carne with Beans (prepared in Bldg 3206)

Ground Beef, Water, Tomato Paste,
Kidney Beans, and other Ingredients

↓

Steam Kettle
300 Btu/serving

↓

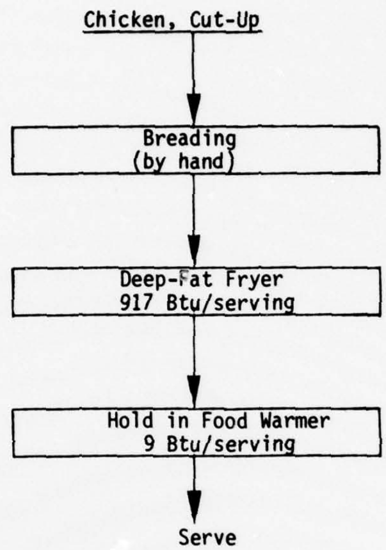
Hold in Food Warmer
9 Btu/serving

↓

Serve

Total 309 Btu/serving

9. Southern Fried Chicken (prepared in Bldg 3206)



Total 926 Btu/serving

APPENDIX E

ENERGY ACCOUNTING OF CENTRAL FOOD PREPARATION SYSTEM

	CFPF - Building #6220		IPF - Building #7118	
	10-19 Oct 78 Increased Prod. Period, 10 days	23 Oct - 30 Nov 78 Reg. Prod. Period 37 days	10-19 Oct 78 10 days	23 Oct - 30 Nov 78 37 days
1. Gas, Btu x 10^6	74.10	213.32	Not used	Not used
2. Electricity, Btu x 10^6	82.80	320.50	0.60	2.90
3. Steam (operating), Btu x 10^6	106.60	384.57	49.73	170.44
4. Steam (space heating), Btu x 10^6	*	172.30	*	40.50
5. Total energy input, Btu x 10^6	263.50	1,090.69	50.33	213.84
6. Production days (excluding weekends)	8	27	8	27
7. Total servings produced	174,658	479,847	84,596** 234,757***	318,486** 689,023***
8. Number of servings produced/production day	21,832	17,772	10,575** 29,344***	11,795** 25,519***
9. Btu x 10^6/production day	32.93	34.01	6.29	6.42
10. Btu/serving (excluding space heating)	1,508	1,914	595** 214***	544** 252***
11. Btu/serving (including space heating)	*	2,273	*	671** 310***
12. *Energy used overnight (no production), Btu x 10^6	4.28	—	—	—
13. *Energy used weekends (no production), Btu x 10^6	17.60	—	—	—

Notes:
*Space heating was not necessary during this period.
**Actual servings produced (salads, gelatin desserts, and slicing cold cut meats).
***Including actual servings produced, ingredient scaling, and meat forming.

APPENDIX F

ENERGY ACCOUNTING OF DINING HALL OPERATION

	Bldg #8402	Bldg #3701	Bldg #3206
	12,141 sq. ft.	4,700 sq. ft.	9,029 sq. ft.
	23 Oct - 30 Nov 78	23 Oct - 30 Nov 78	13-30 Nov 78
1. Gas, Btu x 10^6	76.13	45.62	19.45
2. Electricity, Btu x 10^6	102.20	55.24	25.50
3. Steam (operating), Btu x 10^6	155.92	21.27	13.39
4. Steam (space heating), Btu x 10^6	82.56	28.76	40.43
5. Hot water, Btu x 10^6	240.93	122.05	37.29
6. Total energy input for operating (including space heating), Btu x 10^6	657.74	272.44	136.06
7. Energy used for preparing foods at CFPS, Btu x 10^6	198.61	105.78	5.44
8. Total meals served	58,753	35,704	9,829
9. Number of serving days.	37	34	15
10. Average number of meals served per serving day.	1,588	1,050	655
11. Btu/meal (including space heating)	14,575	10,593	14,396

APPENDIX G

ECONOMIC ANALYSIS OF ENERGY COSTS IN CENTRAL FOOD PREPARATION SYSTEM

	CFPF - Building #6220		IPF - Building #7118	
	10-19 Oct 78 Increased Prod. Period, 10 days	23 Oct - 30 Nov 78 Reg. Prod. Period, 37 days	10-19 Oct 78 10 days	23 Oct - 30 Nov 78 37 days
1. Gas, cu. ft.	74,100	213,320	Not used	Not used
Cost ($)	220	640		
2. Electricity, kWh	24,260	93,905	176	850
Cost ($)	970	3,756	7	34
3. Steam (operating), lb	104,510	377,029	48,754	167,098
Cost ($)	345	1,244	161	551
4. Steam (space heating), lb	45,657	168,922	10,725	39,706
Cost ($)	151	557	35	131
5. Total energy cost ($)	1,686	6,197	203	716
6. Total servings produced in period	174,658	479,847	84,596	318,486
7. Cost/serving (¢)	0.97	1.29	.24	.22

APPENDIX H

ECONOMIC ANALYSIS OF ENERGY COSTS IN DINING HALL OPERATION

	Satellite		Non-Satellite
	Bldg #8402 12,141 sq. ft. 23 Oct - 30 Nov 78	Bldg #3701 4,700 sq. ft. 23 Oct - 30 Nov 78	Bldg #3206 9,029 sq. ft. 13-30 Nov 78
1. Gas, cub. ft.	76,130	45,620	19,450
Cost ($)	228	137	58
2. Electricity, kWh	29,944	16,185	7,471
Cost ($)	1,198	647	299
3. Steam (operating), lb	152,863	20,852	13,127
Cost ($)	504	69	43
4. Steam (space heating), lb	80,941	28,196	39,637
Cost ($)	267	93	131
5. Hot water, gal	320,812	162,517	49,654
Cost ($)	610	309	94
6. Cost of servings received from CFPS ($)	1,091	572	16
7. Total energy cost ($)	3,898	1,827	641
8. Total meals served in periods	58,753	35,704	9,829
9. Cost/meal (¢)	6.6	5.1	6.5